Distributed Sensor Network for Retargeting

one of two Army Research Laboratory parcels
of Multi-Role Armament and Ammunition Suite ATD

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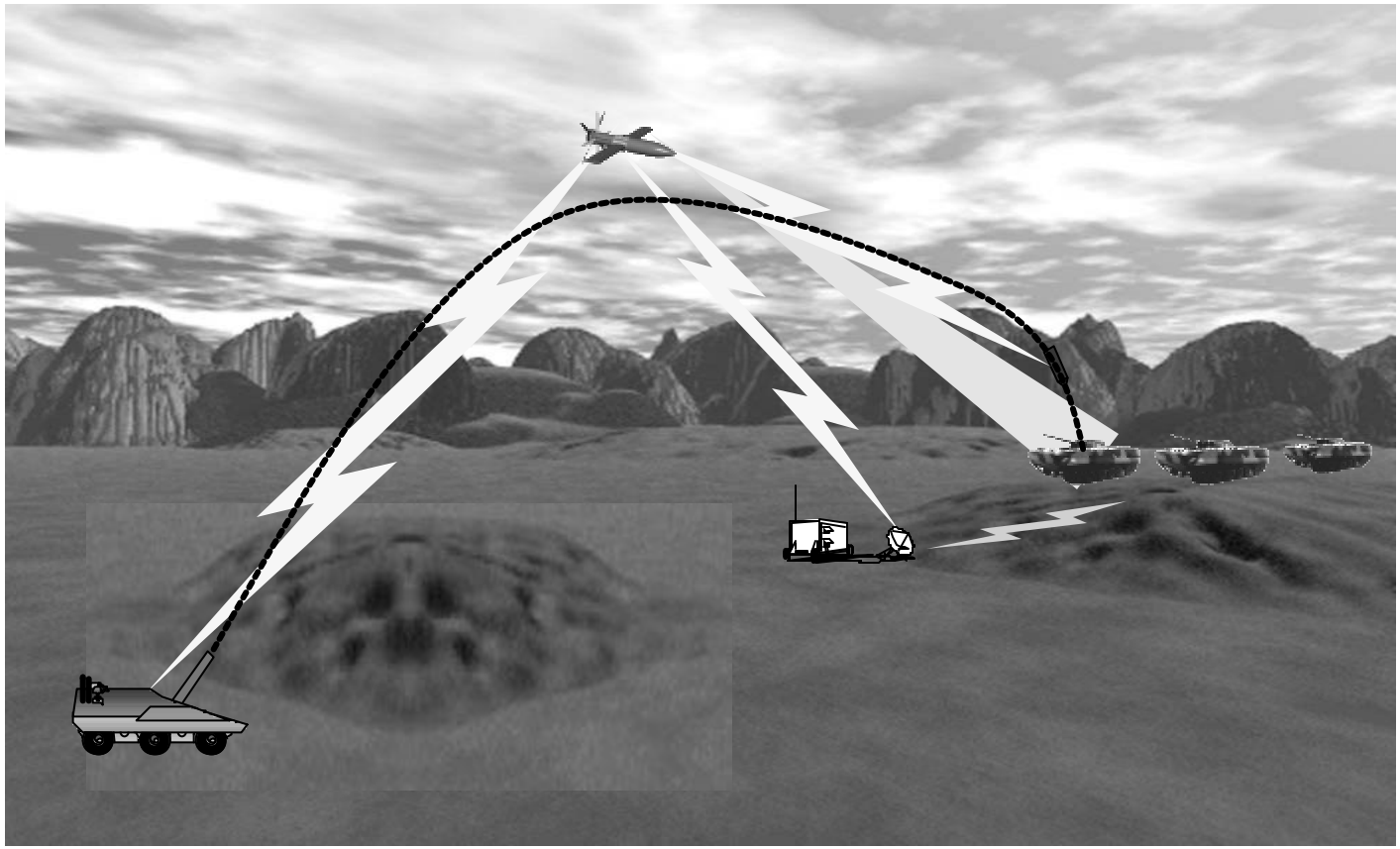

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Abstract

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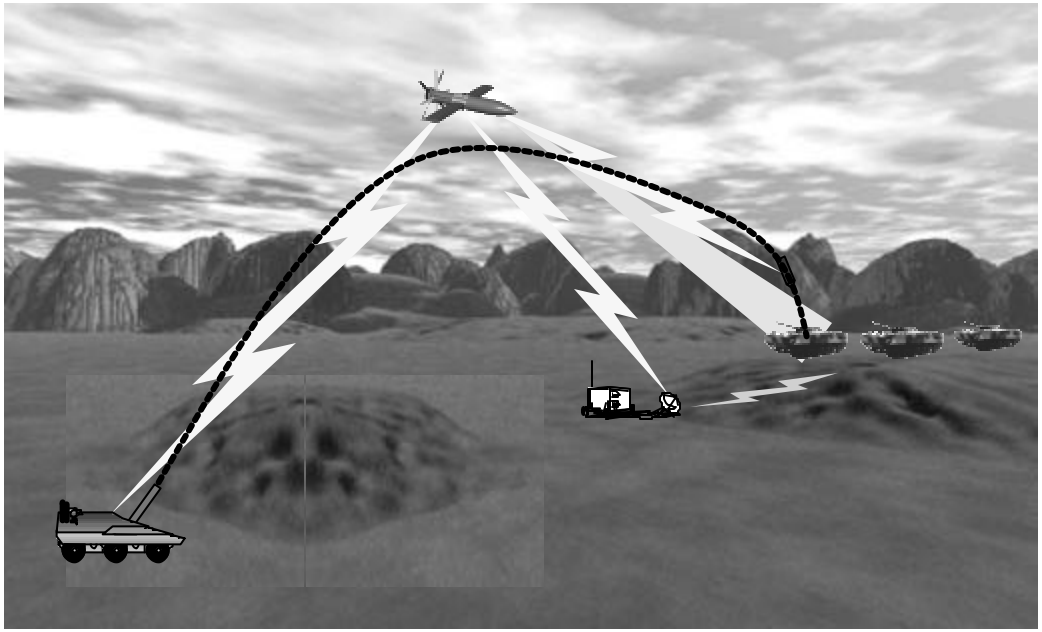
22

Distributed Sensor Network for Retargeting

for Multi-Role Armament and Ammunition Suite ATD

Objective: Conceive, model, and assess approaches to dynamic re-targeting within a simulation framework that permits virtual experimentation.



Technical Approach:

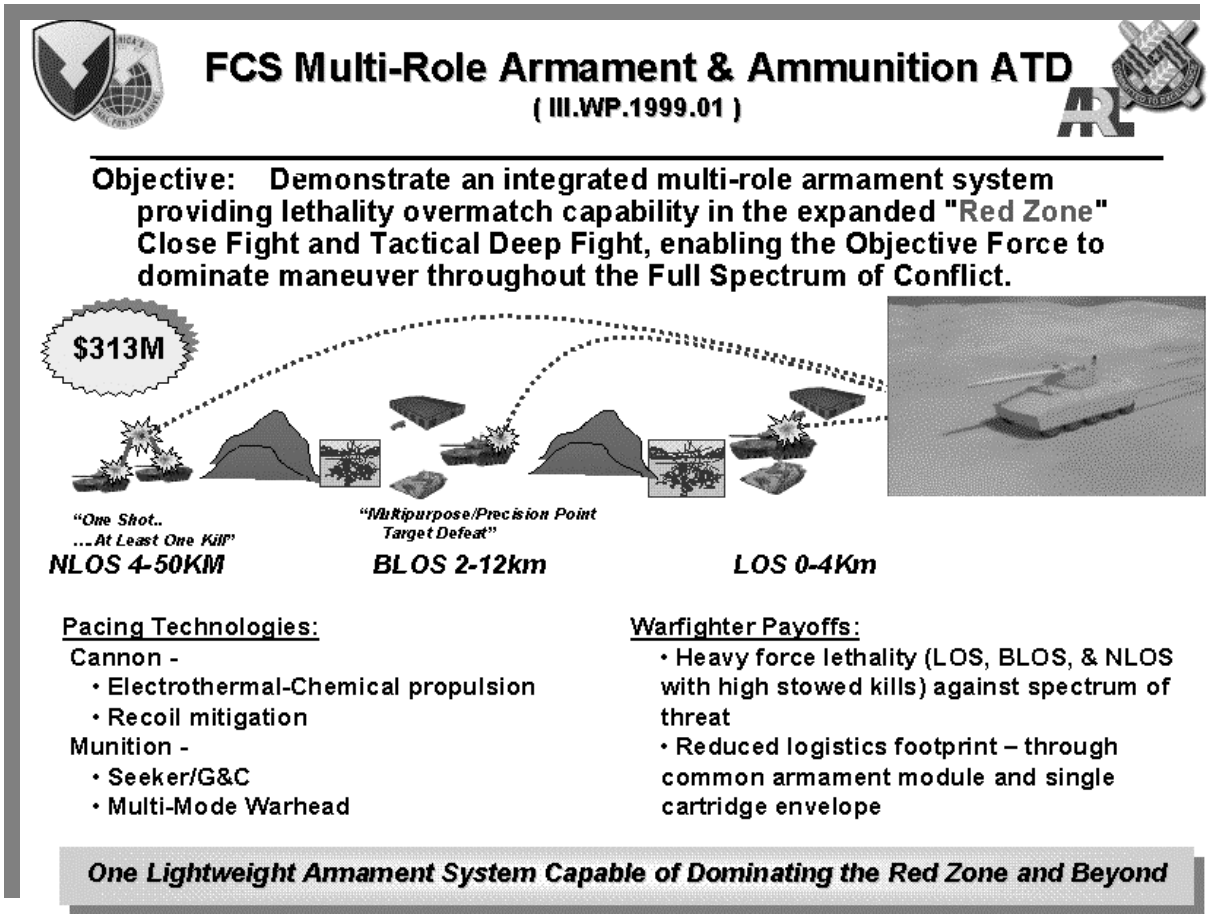
- Develop simulation framework that integrates digital map data, sensor models, target models, networking, communication, and battlefield dynamics.
- Model FCS-compatible targeting sensors.
- Evaluate potential for new sensor capabilities to provide relevant and timely location information for indirect-fire extended range munitions.

Benefit: Permit trialing of notional networks of sensors and assessment of enabling capability of "one shot…at least one kill…"

Status:

- Developed initial simulation framework that integrates digital map data, RF sensor models, simple target models, and battlefield dynamics.
- Developed Graphical User Interfaces to define sensor and target configurations.
- Integrated two RF sensor models.

"One Shot, …at Least One Kill" - Extraordinary Demands on Sensors



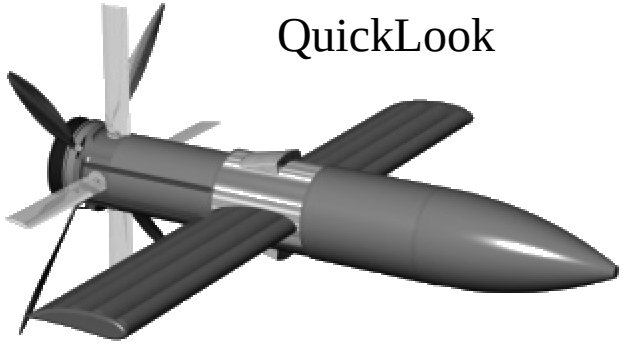
- The Targets Must be Detected and Located,
- Ideally, Signature Data will be Uplinked Dynamically (or, In Flight).
- Distributed Micro-Sensors Helps Provide the Eyes and Ears for this Emerging System

FO/Scout Options

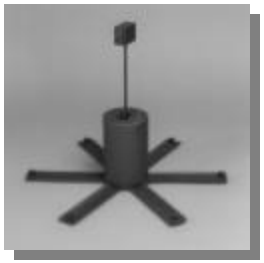
Thermal Weapon Sight

MULES

QuickLook



TUAV



UGS

Future Scout Vehicle

Key Attributes of Planned Effort

- Construct a dynamic environment capable of monitoring crucial issues such as battery life, tracking accuracy, and effectiveness of cross-cueing strategies.
- Determine the amount of militarily significant information available (i.e., Probability of detect, location accuracy, timeliness, etc.) from notional sensor networks.
- Use as a yardstick to judge the value of individual sensor technologies and their complexity.

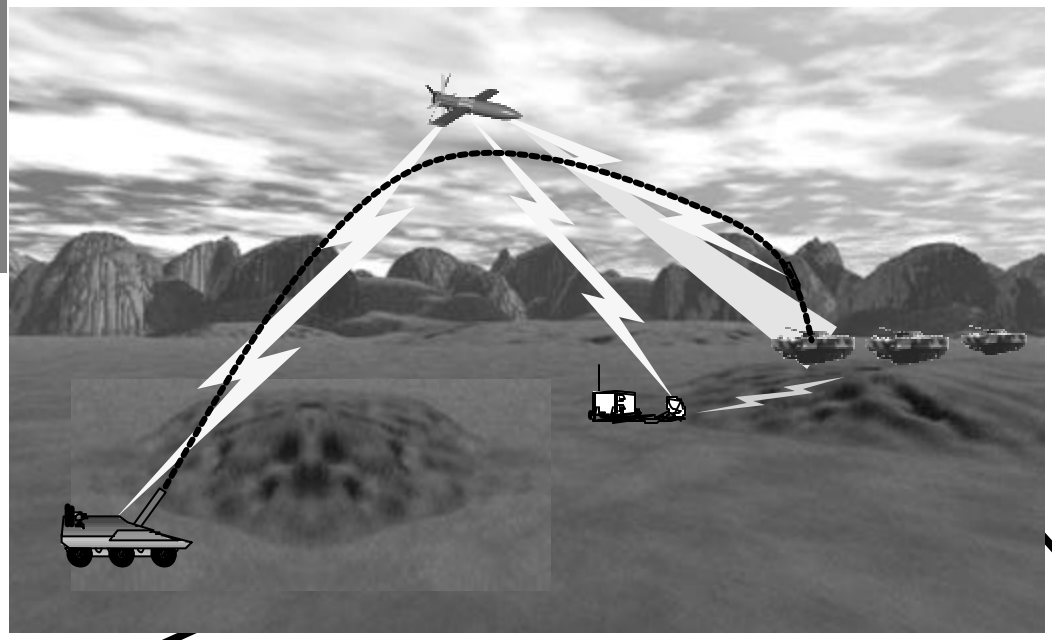
(Just Some) Crucial Issues

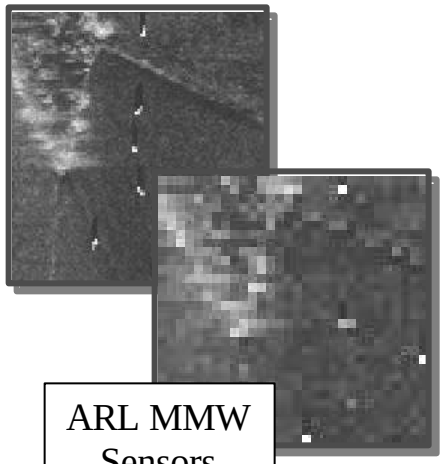
- Sensor Deployment Concept
  - Loitering Micro-UAV
  - Unmanned Ground Sensors Deployed from Artillery, UAV, UGV, etc.
- Sensor Mobility/Relocatability
- Sensor Recoverability
- Individual Sensor Location Accuracy
- Individual Sensor Performance
  - Sensor Coverage Map and Near-Ground Propagation Effects
  - Resolution
- Autonomous Network Command, Control and Cueing
  - Self-organizing ad hoc networks
- Sensor Fusion
  - Within Class - Tracking and Beamforming
  - Between Class - Refined Detection, Tracking and Classification

Two Significant Capabilities Needed

HDL Heritage

ARL WEBS Activities





ARL MMW Sensors Research

Detect and Locate the Targets to be Engaged

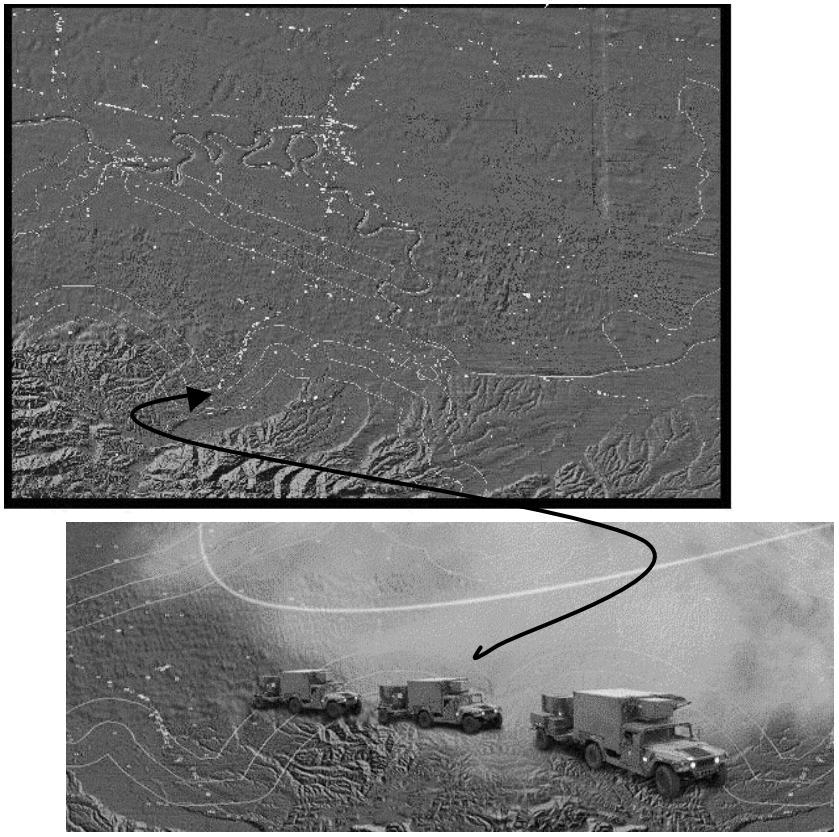
DARPA FCS Activities

AMCOM's ATR for Conventional Weapons STO

Update Munition in Flight

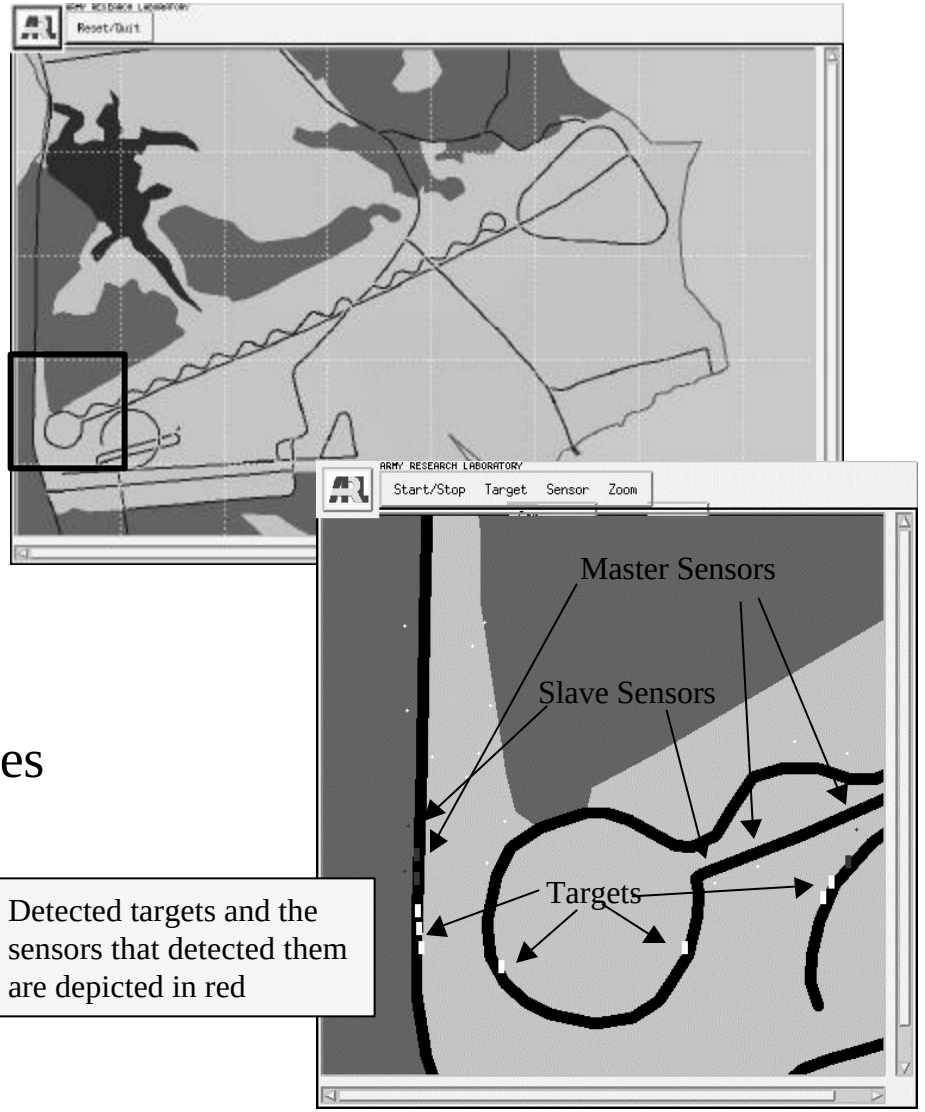
Initial Strategy

- Develop an Overarching Framework for Experimentation
    - Brigade-Sized Playing Field
    - Identify Variables to be Modeled and Monitored
- Concentrate on a Lucrative Sensor Concept and Construct Appropriate Sensor Performance Model
    - L-Band Multi-Function Sensor
- Place Sensors in a Faithful Battlespace Representation
    - Include Elevation and Feature Data Bases
- Exercise Dynamics of the Battlespace
- Assess Sensor Complexity Versus Military Utility of the Sensor Outputs
    - Monitored Outputs Compatible with WMRD Needs



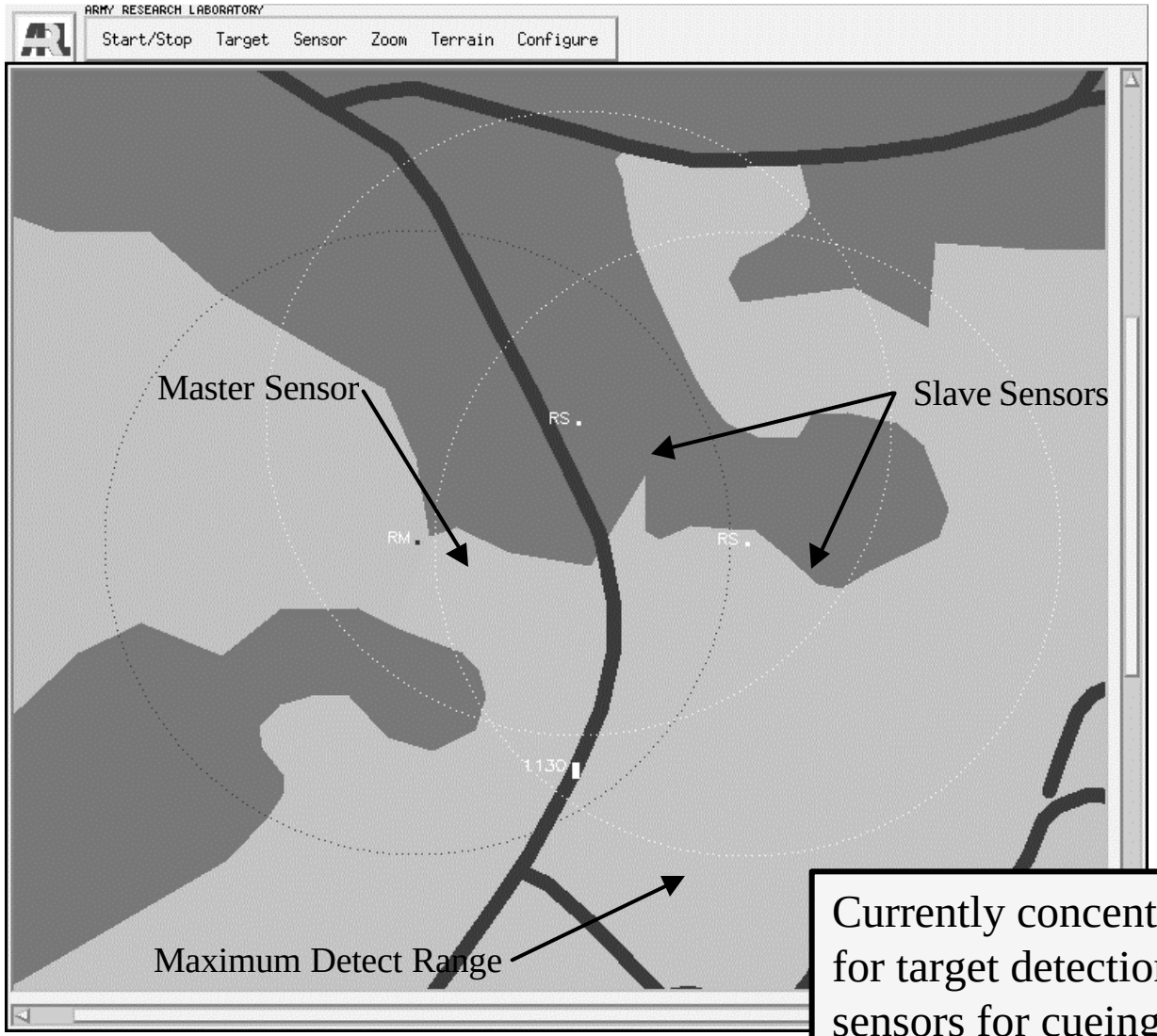
Simulation Procedure

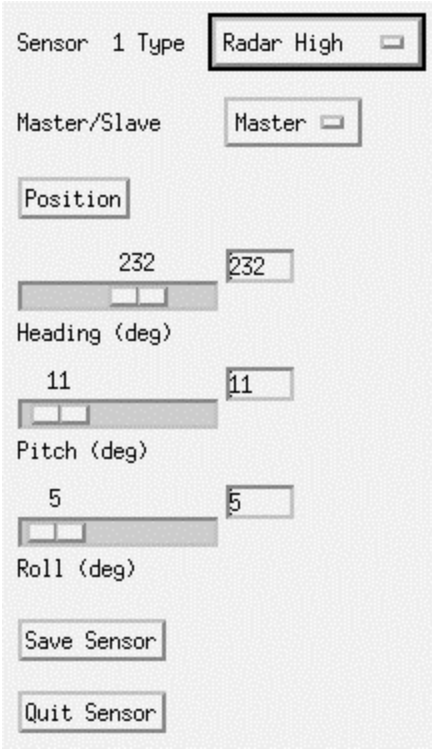
- Enter Digital Map Data
  - Terrain characteristics
- Deploy Individual Sensors
  - Performance characteristics/ coverage map
- Define Cueing Strategy
  - Passive sensors “wake up” active sensors
- Develop Target Scenarios
  - Type, initial position, speed and path
- Monitor Sensor Performance Attributes
  - Target detected
  - Information dissemination
  - Battery life
- Playback and Assess



Detected targets and the sensors that detected them are depicted in red

GUI for Custom Sensor Configuration





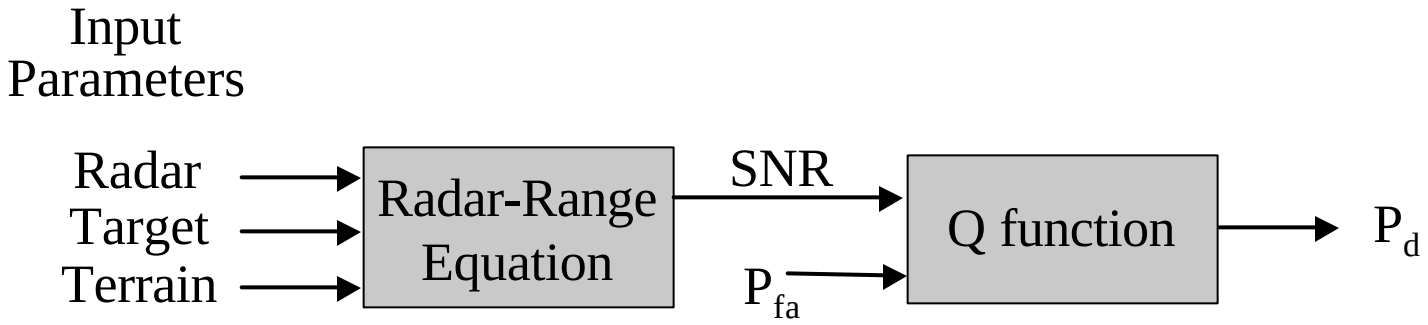
Currently concentrating on L-band RF sensors for target detection with acoustic and magnetic sensors for cueing.

Simulation of RF Sensors

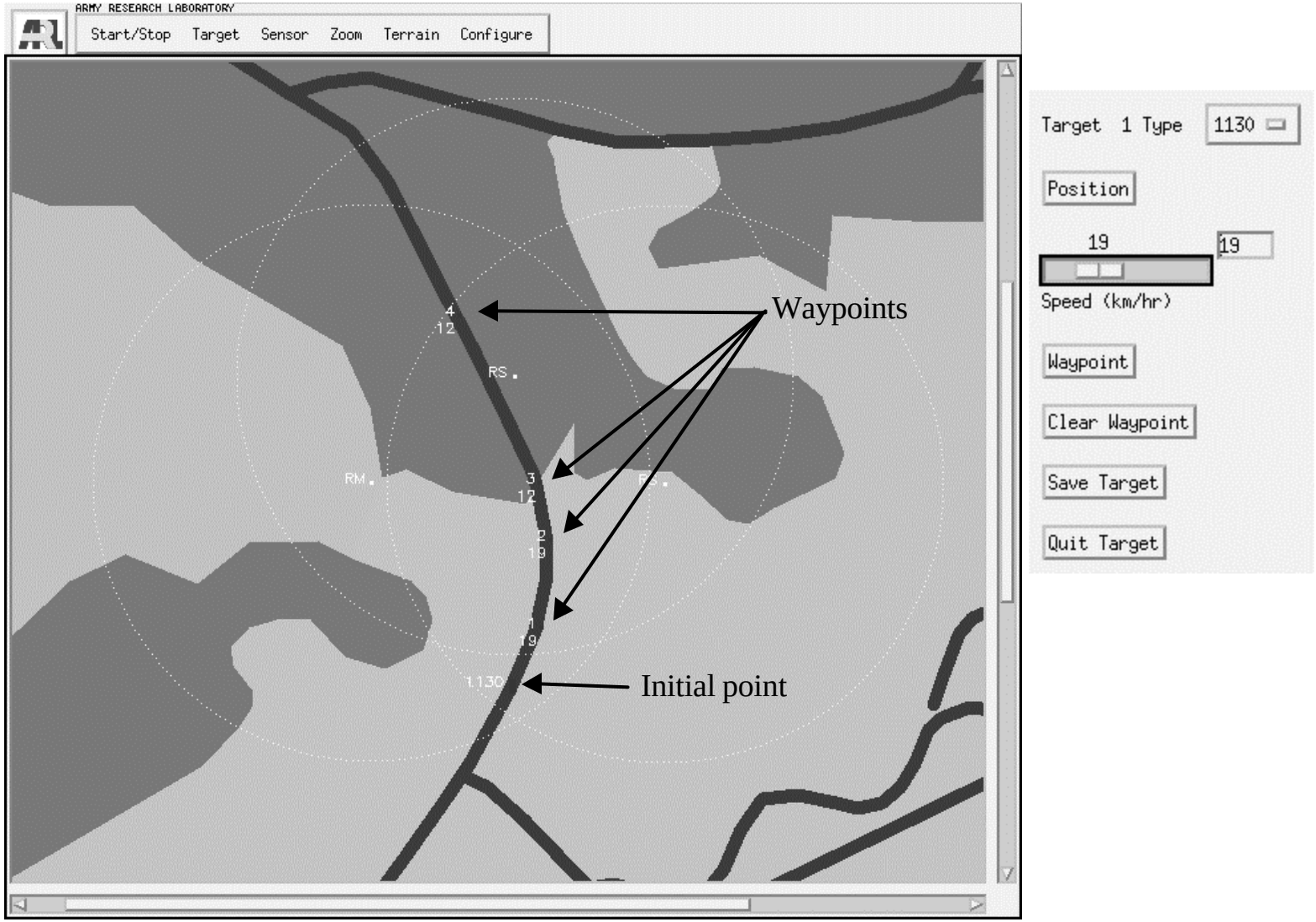
Modular software package capable of performance predictions for variety of radar systems.

- step-frequency to chirped waveforms.
- stationary to airborne systems.

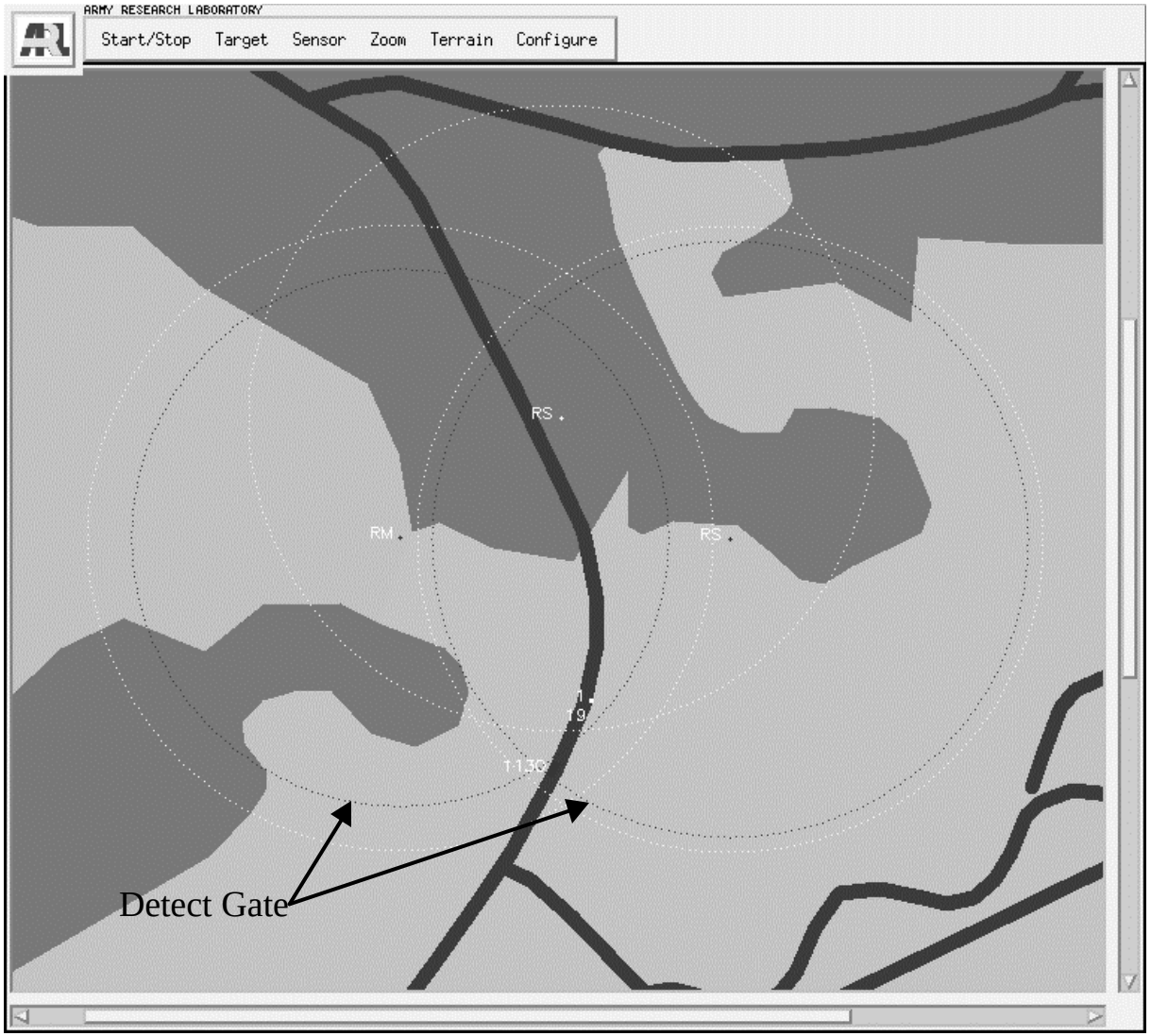
Calculate detection probability for each velocity, range-gate cell



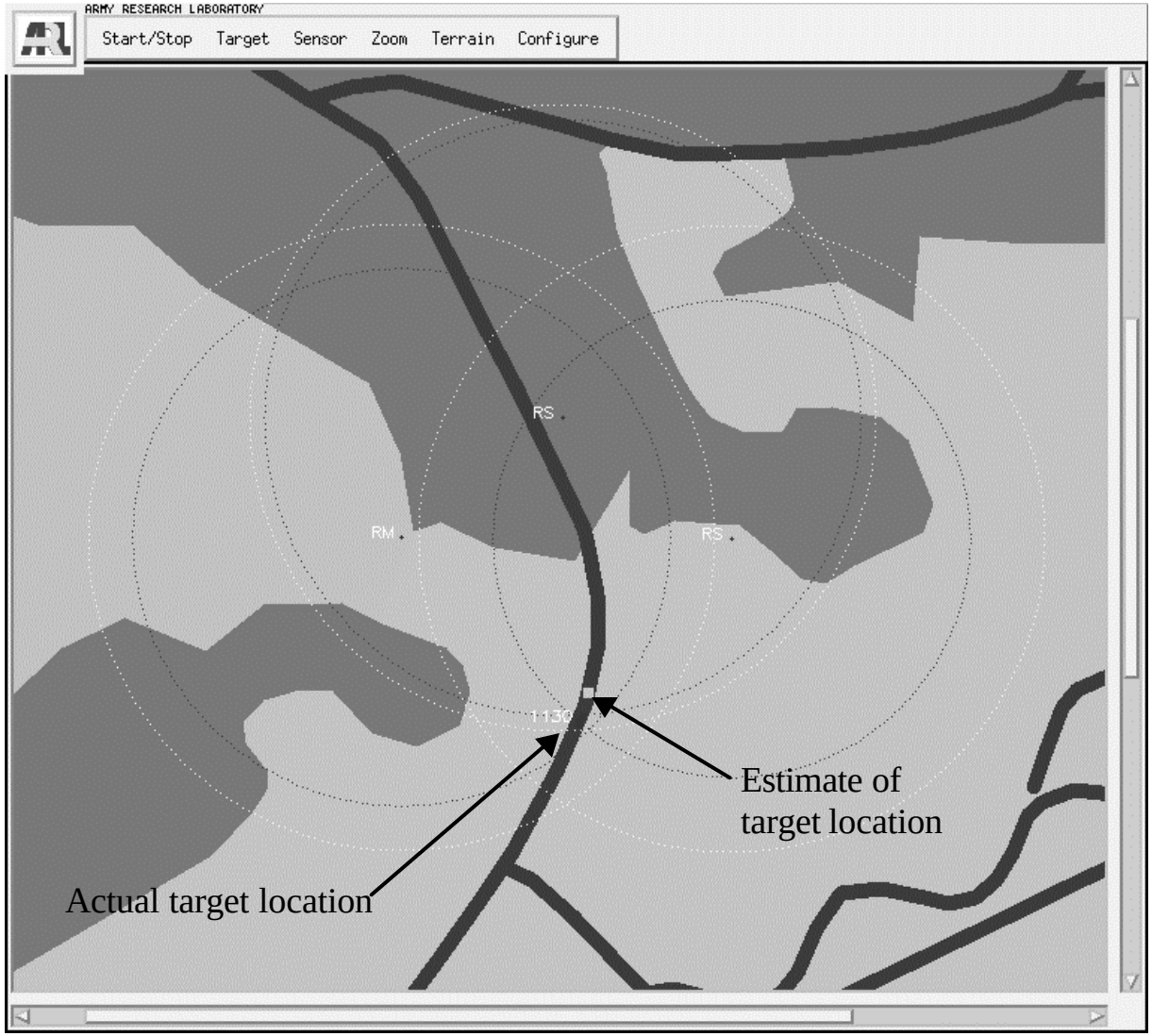
GUI for Custom Target Configuration



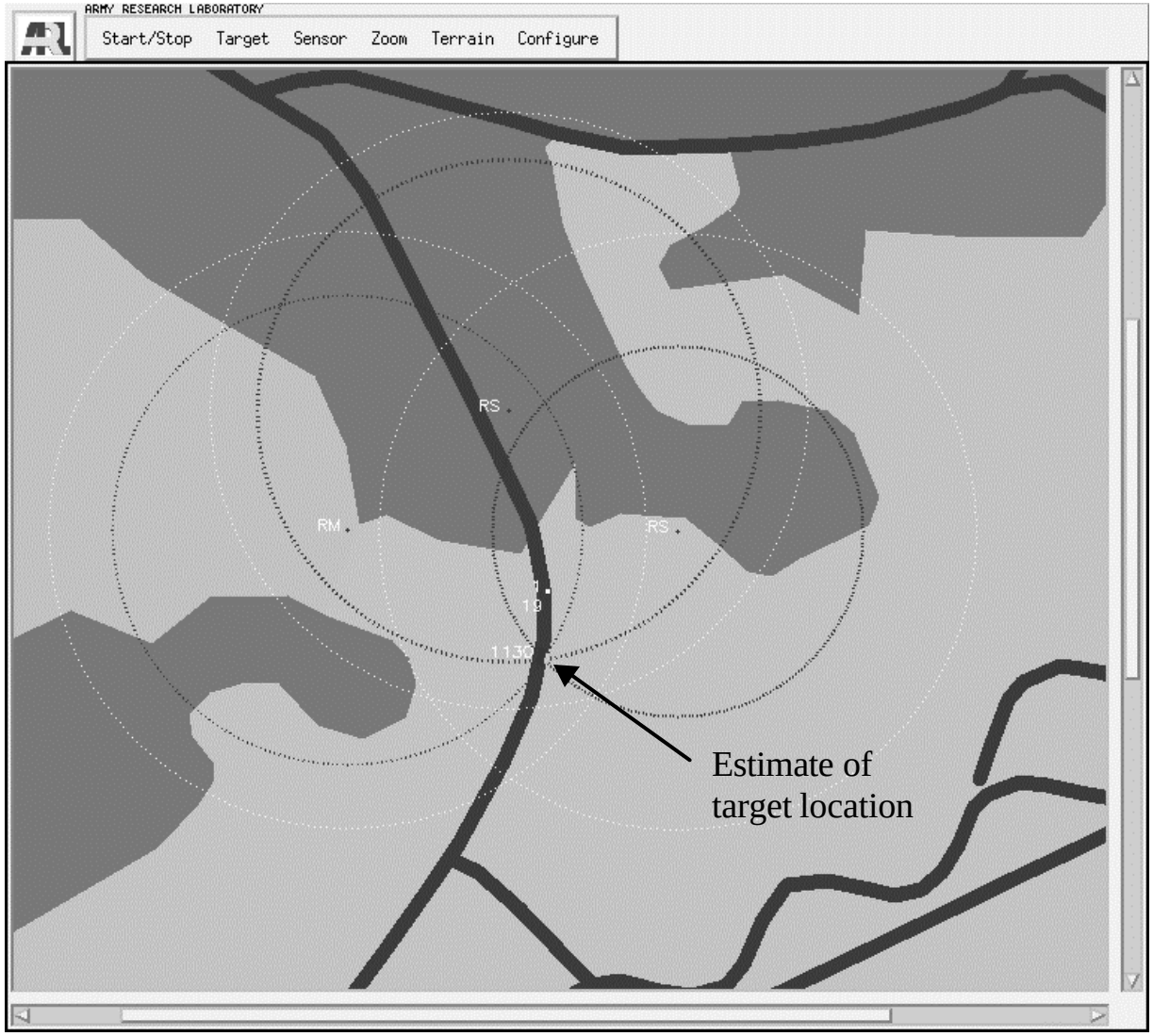
Target Detects



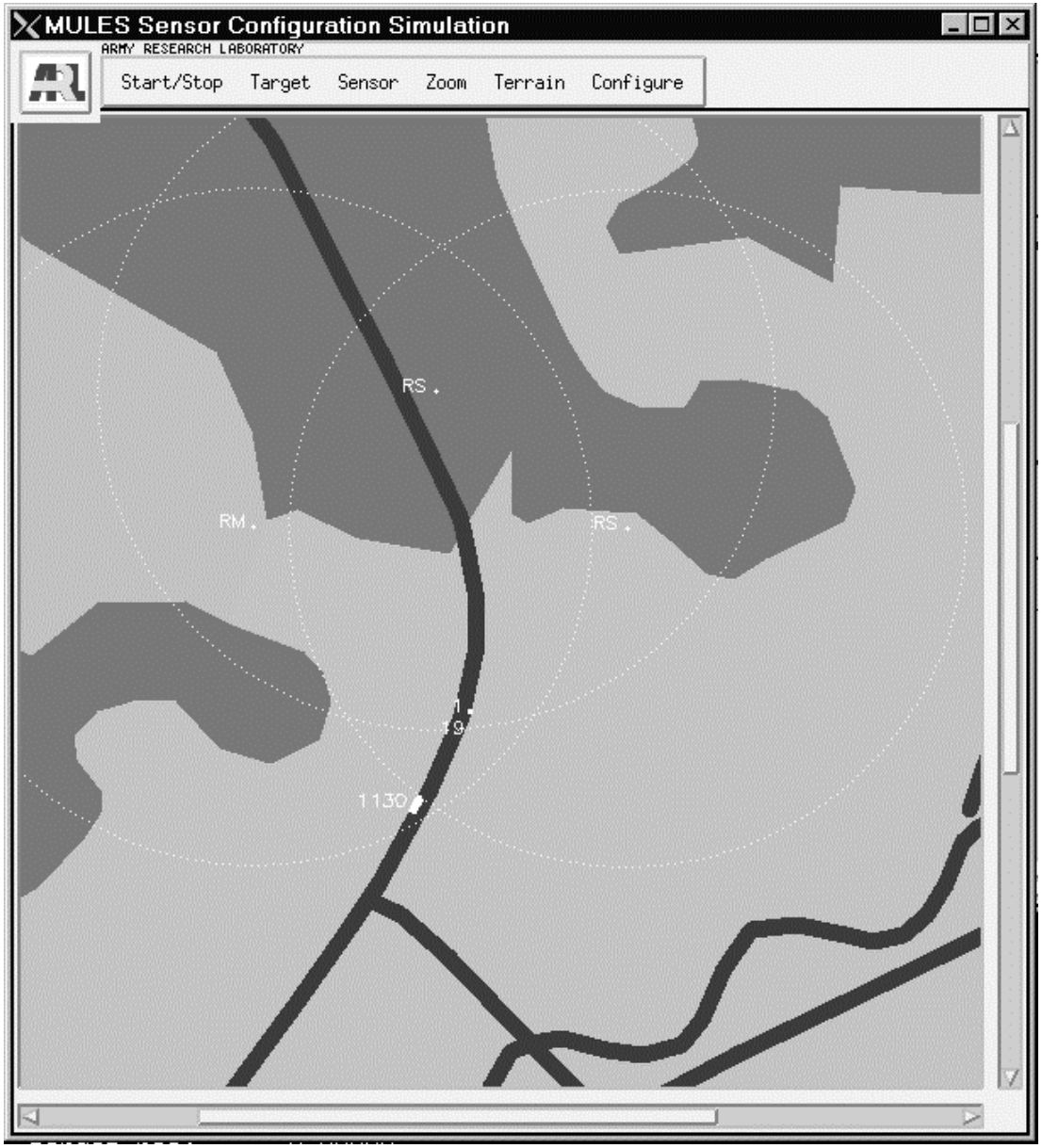
Fusion of Detects of Low Resolution Sensors



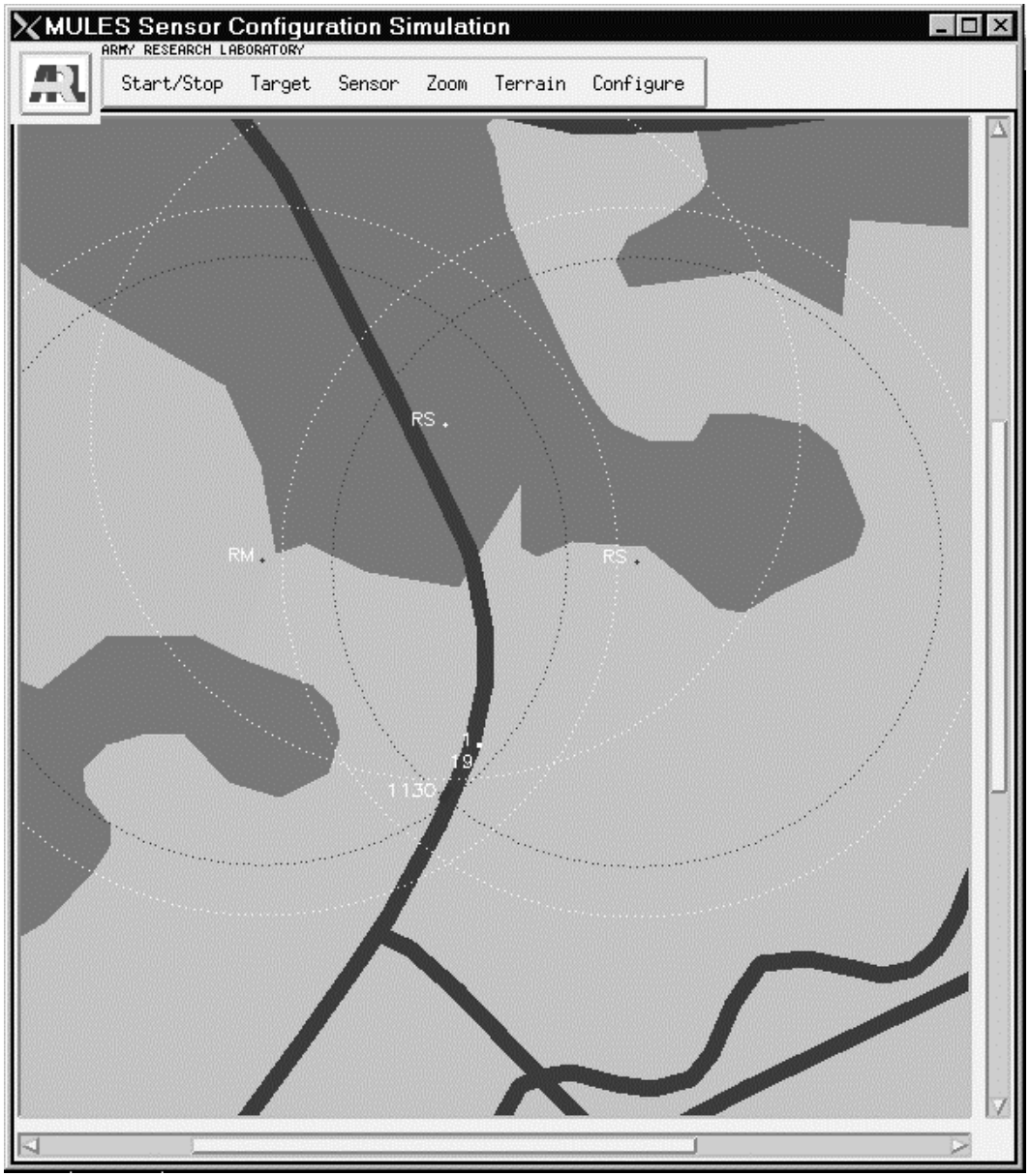
Fusion of Detects of High Resolution Sensors



Estimator of Target Position for Sensors with High Resolution Gates



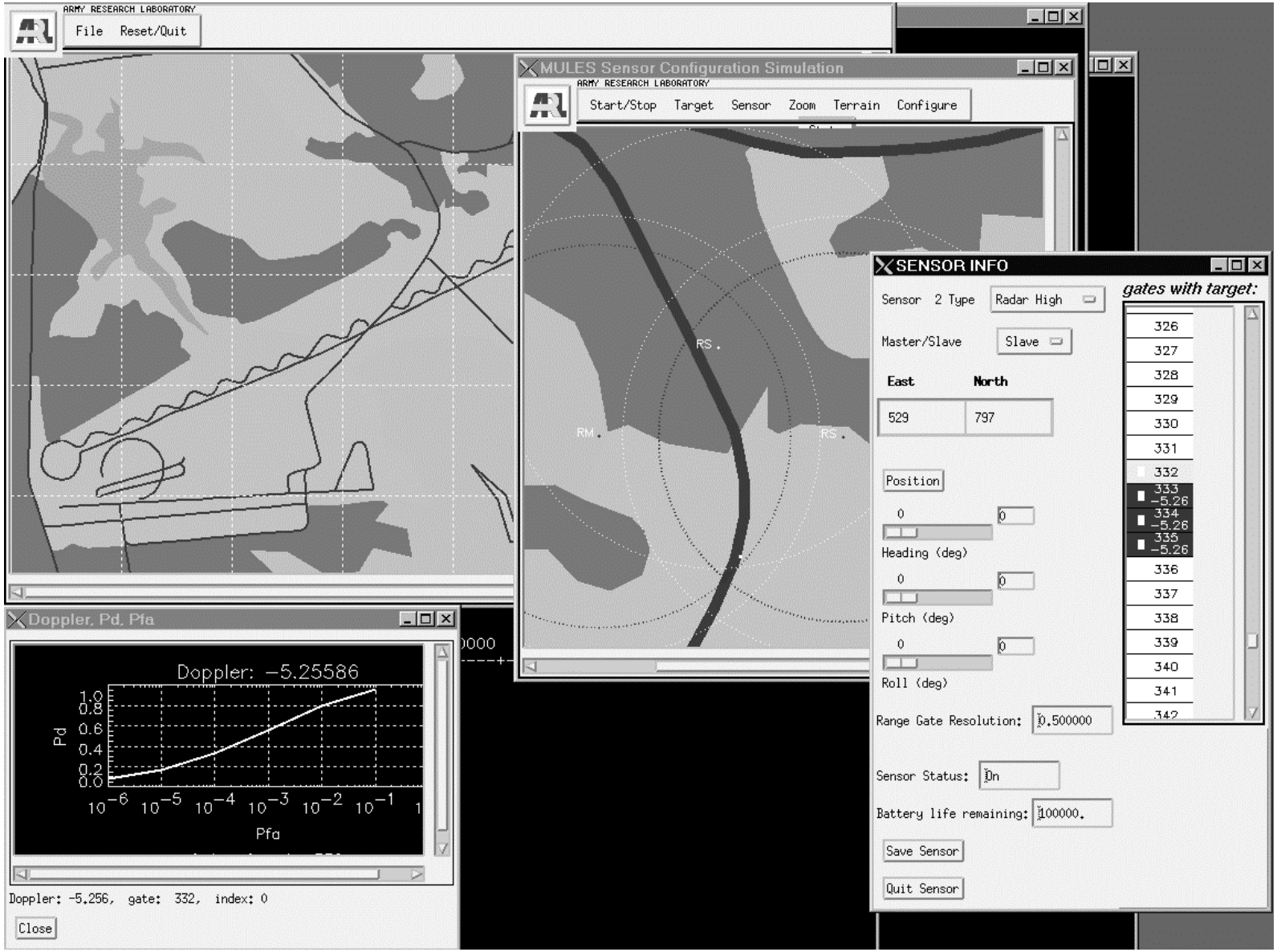
Estimator of Target Position for Sensors with Low Resolution Gates



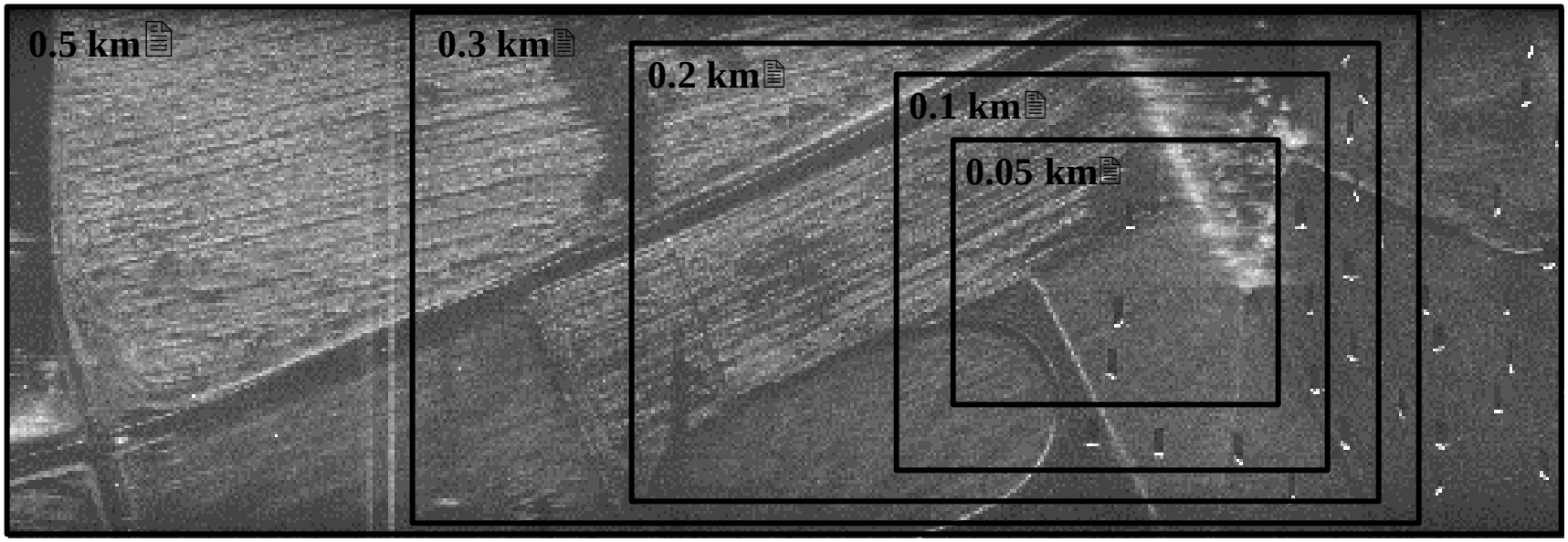
How is Simulation Used to Evaluate Performance?

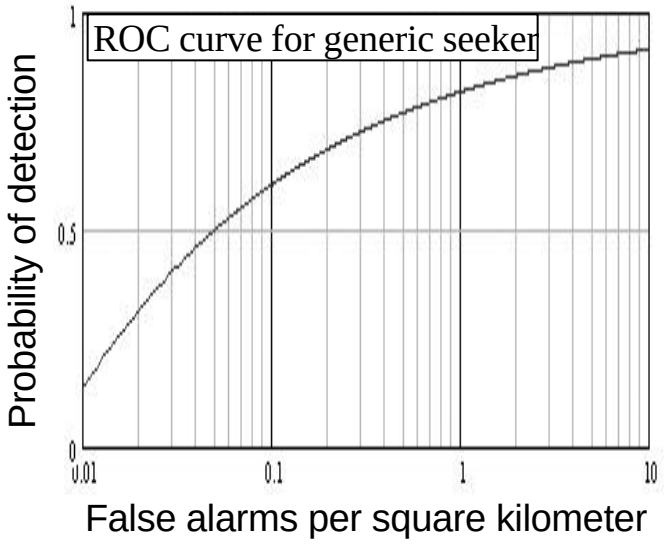
- Perturb Sensor Model
  - Trial Various Levels of Sophistication
- Vary Deployment: On-road versus Random
- Evolve Cueing Strategies
  - Who Turns Who On When, and for What Reason
- Ascertain Overall System Performance
  - Potentially in a Monte-Carlo Fashion

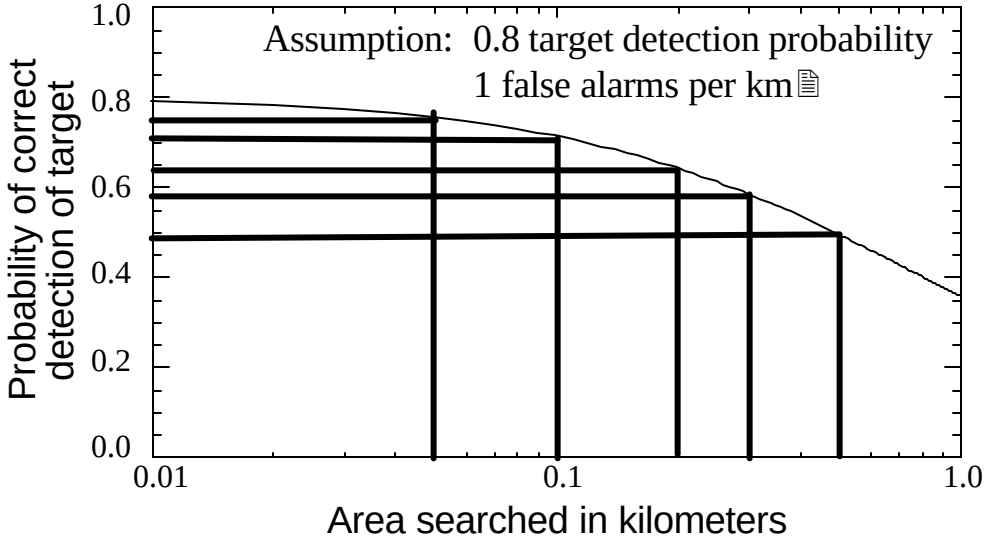
Analysis of Detect



Probability of correct detection vs. search area







Probability of Detection vs. Probability of Engagement for a Moving Target

Search Area	Probability of Encounter*	False Alarms per Sq. Km	Effective Probability of Detect**	Cumulative Probability
100mx500m	0.22	1.0	0.75	0.16
		0.1	0.80	0.18
300mx500m	0.56	1.0	0.70	0.39
		0.1	0.79	0.44
500mx500m	0.76	1.0	0.60	0.46
		0.1	0.77	0.58

**** Probability of Encounter[1] for a 300 m/sec flight from 8 km***

***** Probability of Detection for one target = 0.8***

[1] Patterson, Carolyn; *Target Location Error for the Tank Extended Range Munition*, ARL-TR-1433, U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, September 1997.

The greatest improvement in performance can be realized by increasing Probability of Encounter through continuous re-targeting of the munition

Summary

- ARL effort on MRAA ATD is concentrated on determining the timeliness and quality of targeting data
  - Initially focusing on networked micro-sensors (with an RF member)
  - In future, will examine re-targeting and providing real time updates to seeker head
- Program is designed to provide multiple layers of insight
  - At the highest level, pd and location accuracy, for instance
  - At the network level, virtual experimentation of cueing and fusion strategies
  - At the sensor level, the military effectiveness of adding performance versus cost
- By establishing additional battlespace awareness (through virtual experimentation), new sensor technologies and architectures can be better assessed